

P3.34 ASSESSING THE QUALITY AND UTILITY OF HIGHER RESOLUTION GOES SOUNDER RETRIEVALS

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INTRODUCTION: The purpose of this study is to show the utility and the advantage of producing GOES atmospheric soundings at every field of view (roughly, 10km resolution). Historically, in order to reduce the impact of noise, several fields of view have been averaged. Currently, the NESDIS operations is producing soundings at a resolution of five pixels by five pixels, averaging out 25 fields of view. Production at the Cooperative Institute for Meteorological Satellite Studies has long been at 3x3 resolution, averaging nine pixels. Since early in the year 2000, however, the Forecast Products Development Team (FPDT) has been generating GOES soundings at every field of view. Some results from this production are presented herein.

PRODUCT QUALITY ASSESSMENT: The first issue raised in single field of view production is product quality. There was valid reason behind the desire to average a number of fields of view and, thus, produce soundings on a 5x5 or 3x3 basis. The predominant concern was that a lack of averaging, thereby not reducing the impact of noise, could result in cloud contamination.

An analysis of the cloud detection algorithm found that there were several cloud detection tests that were rather "loose" in their cloud/no-cloud determination. As a result, it was speculated that if these checks were made more stringent single field of view soundings could be made without significant cloud contamination. The following table shows the results of radiosonde match statistics taken over a six month period during 2001. It compares the two extreme ends of the spectrum, the single field of view and the operational 5x5 soundings.

	TPW AAE	TPW Bias	Sample
5 x 5	2.54mm	-0.61mm	17635
1 x 1	2.44mm	+0.40mm	24595

*AAE = Average Absolute Error
TPW = Total Precipitable Water*

Clearly, these numbers show no degradation in going to the single field of view production. In fact, the error reduces slightly. The bias is also closer to zero. The reason for the bias being in the opposite direction is not obvious. There could be any number of factors at work here. The most obvious would be that the single field of view soundings will get a lot more soundings near cloud edges (the 5x5 and 3x3 production require a minimum number of clear fields of view before a sounding will be made). This tends to be an area of high moisture gradient. As such, depending on the radiosonde match distance, the radiosonde may have gone through much drier air. As such, the single field of view bias increases relative to the 5x5 production.

The product quality is clearly maintained in single field of view production. Moreover, a simple overall statistic does not paint the entire picture. Take, for example, a user utilizing the GOES soundings for convective forecasting. In these cases it is the lower levels of the sounding that are most critical, as these define the parcel, thereby greatly impacting the convective parameters (Lifted Index, CAPE, etc.). The

following table shows the radiosonde match statistics for precipitable water in layer one (PW1, from the surface to 0.9 sigma).

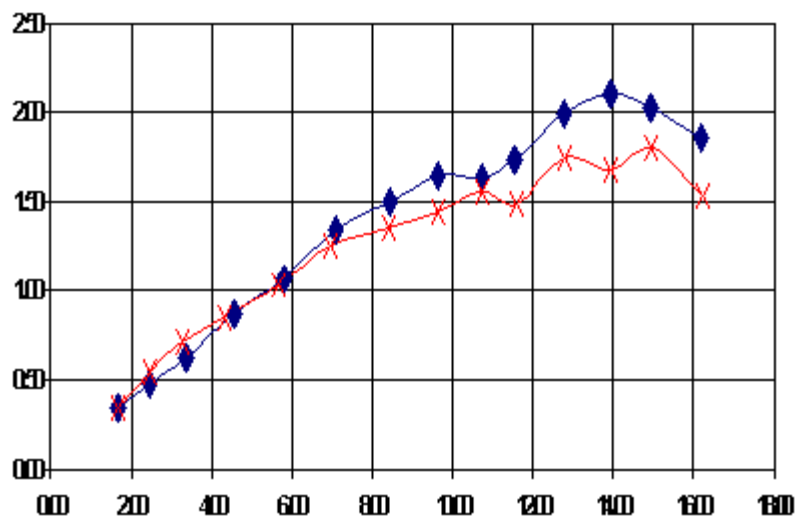
	PW1 AAE	PW1 Bias	Sample
5 x 5	1.40mm	-0.75mm	17635
1 x 1	1.22mm	-0.57mm	24595

AAE = Average Absolute Error

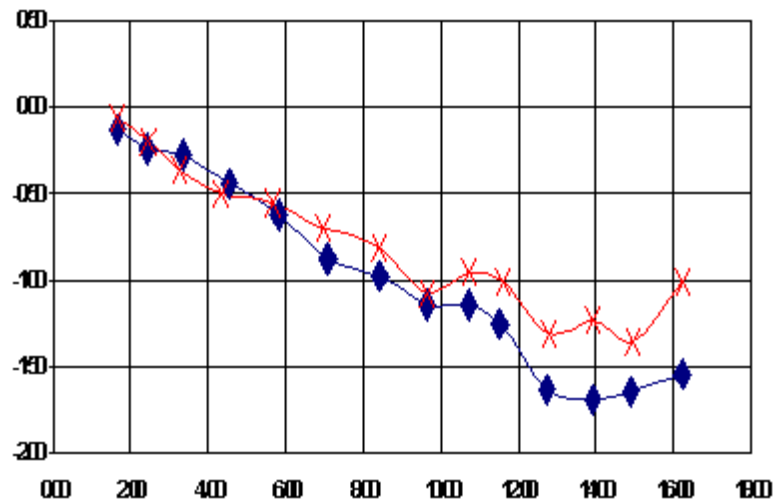
PW1 = Layer-1 (sfc to 0.9 sigma) Precip. Water

This table shows that the single field of view soundings have even more success over the 5x5 production in this low layer. There is greater error reduction and the bias is, again, closer to zero.

Still, this tells only half the story. As it turns out, the success of the 1x1 soundings is focused in areas of higher moisture. These are, of course, areas more critical to those concerned with the prediction of convective events, excessive rainfall, etc. The following two graphs show the PW1 average absolute error and bias, respectively, with respect to increasing radiosonde precipitable water.



The above chart of PW1 absolute error shows the error (Y-axis) with respect to PW1 amount (X-axis) in millimeters. Note the divergence of the two lines beyond roughly 6mm. The line with the higher error represents the 5x5 GOES soundings production from GOES-8; the lesser error is from the 1x1 GOES-8 soundings production.



The preceding chart of PW1 bias shows the bias (Y-axis) with respect to PW1 amount (X-axis) in millimeters. Note the divergence of the two lines beyond roughly 6mm. The line with the more extreme negative bias represents the 5x5 GOES soundings production from GOES-8; the closer to zero bias is from the 1x1 GOES-8 soundings production.

These charts leave no doubt that 1x1 soundings are not only no worse, but are, in fact, superior in quality to their lower resolution counterparts.

PRODUCT UTILITY ASSESSMENT: Raw data quality is not the only measure of the usefulness of the single field of view data. There are also other beneficial aspects of the single field of view data.

The most obvious advantage in data utility is the higher resolution of the product. However, more data is not only the result of increased resolution. As mentioned earlier, the 5x5 and 3x3 productions require a minimum number of clear fields of view before the sounding is output. Obviously, by its nature, 1x1 production has no such requirement. As a result, if a sounding is attempting to be retrieved near a cloud the 5x5 box may, for example, only identify four clear fields of view, while the 3x3 identifies two. Neither system will output any product data for this location. However, the 1x1 production will output all available clear fields of view. The only reduction in product output could come from the more stringent cloud detection tests, as noted earlier. However, the data most likely to be discarded by this effect is potentially cloud contaminated. So, this data loss is of small quantity and is data whose loss is actually of benefit to the product.

Also, this increased resolution is not simply a greater amount of data. The lack of averaging also allows for improved display of gradients. Consider that a 5x5 soundings box is, roughly, 50km X 50km. While variations over that distance may tend to be small, they can occasionally be significant in the moisture field. For example, if a pocket of increased moisture exists (which could eventually be the focus for convection) the pixels on the left side of a 5x5 box may represent an atmosphere containing 30mm of total precipitable water (TPW). Meanwhile, on the right side the pixels could represent the pocket of moisture with, say, 35 to 40mm of TPW. The 5x5 box to the right of this may have the mirror image as one exits the moisture pocket. As a result, both 5x5 retrievals may end up with a smoothed TPW of roughly 35mm. Single field of view soundings, however, will represent each pixel individually. As such, so long as the moisture pocket exceeds a 10km by 10km size, the gradient will be fully represented.

The following three images show the Lifted Index from the GOES Soundings over the central United States from the 5x5 production, 3x3 production, and 1x1 production, respectively.



It is obvious that the 1x1 production provides a much higher resolution, much more detailed product. However, also notice near the missing data regions on the 5x5 and 3x3 fields (determined to be cloudy, although little is evident in this imagery); in some regions it is not simply a matter of there being *more* data in the single field of view production. Rather, there is data where the 5x5 and 3x3 production had *none*. This is most notable in the northeastern part of these images. Notice that the 5x5 has no sounding east of the -3 L.I. value in the top row of data. In the same general region, the 3x3 field has no sounding either

east or south of the -4 value at the eastern end of the top row of data. This is because these attempted soundings locations failed to meet the minimum clear field of view requirements. The 1x1 data, however, will make a sounding at every possible location. Notice that it has only a tiny data gap in that area.

Along with the increased amount of data, as discussed in general terms earlier, these images provide a good example of the improved gradient depiction. The smoothing of the fields on the 5x5 provides virtually no gradient in this Lifted Index field. In the 3x3 display the gradients become more evident, with -3 values in the southeast part of the image and -4s and -5s (even one -6) in the west. Still, it is somewhat of a washed out gradient. The single field of view product, however, shows the gradient well. This is especially true up into the northwest part of the image where Lifted Index values drop to -6.

More specifically, in this example provided the region displayed is west-central Wisconsin and extreme east-central Minnesota. The time of the plot is during the overnight hours (04Z). Rather strong thunderstorms moved into the region in the morning, especially around Eau Claire, WI and heading towards La Crosse, WI. Focusing in on that area is virtually impossible with the 5x5 retrievals. The Lifted Index values are a touch lower in the general region around Eau Claire and La Crosse, but not significantly. The 3x3 soundings are better, but are still rather broad-brushed, making for a difficult analysis. The high-resolution 1x1 field, however, clearly shows a patch of L.I. values of -5 to -6 roughly from Rochester, MN to Eau Claire, WI. Other scattered -5 to -6 values continue southward near the WI-MN border, including near La Crosse. Meanwhile, the entire remaining regions of Minnesota and Wisconsin have Lifted Index values between -1 and -4. In short, the single field of view production provides a distinct focus to the convective activity, which proved to be correct, that the 3x3 and 5x5 were marginal, at best, in depicting.

The higher resolution is not just an advantage for those using the data in real-time for situational analysis. It is also an advantage from an NWP standpoint. Note that data from the GOES soundings is being ingested into the ETA model. Current plans for the ETA model have it going to 12km resolution before the end of the year 2001. Having GOES soundings at almost the exact same resolution could make the assimilation of the data an easier task. Easier or not, it certainly makes the assimilation more accurate as the soundings data more precisely represents the related grid cell in the model field. Assimilation of the current operational data into such a high resolution model would mean that 2500km² GOES soundings (50km X 50km) would be used to influence model grids an order of magnitude smaller in coverage (12km X 12km = 144km²).

CONCLUSION: The single field-of-view GOES soundings are clearly the most desired and optimal production level. The data presented herein shows the quality of the single field-of-view data to be slightly superior to that of the 5x5 production. Comparison statistics were not readily available for the 3x3 production. However, past studies including the 3x3 data yielded similar results. Also, the cloud detection modifications made for 1x1 production were exclusive to the 1x1; in other words, 3x3 production is more similar to 5x5 production than 1x1. Note also that all data presented herein is from GOES-8. This satellite suffers from worse noise than GOES-10, and should be worse than GOES-11 or GOES-M as well. Recall that a primary argument for *not* producing single field-of-view soundings is the noise. If quality improvements can be shown in 1x1 production with GOES-8, it is almost a foregone conclusion that the other GOES satellites will also benefit. Statistics have been run for GOES-10 with very similar results as GOES-8. The overall GOES-10 statistics show a smaller, almost negligible improvement in the 1x1 soundings over the 5x5 soundings. However, this is due to the drier atmosphere typically sampled by GOES-10. The high-PW soundings from GOES-10 yield similar improvements in the 1x1 over the 5x5.

Moreover, the quality improvements were most distinct in the lowest layer. This layer has the greatest impact on many ancillary fields used by forecasters and others. This further enhances the quality improvements seen in the 1x1 production.

Besides the quality improvements, the 1x1 fields also yield a coverage improvement. The coverage improvement is two-fold; where the 5x5 or 3x3 retrieve one sounding, the 1x1 will retrieve as many as 25 or 9, respectively; secondly, where the 5x5 or 3x3 retrieve no sounding, the 1x1 *may* still retrieve a few

soundings in that region. This improved coverage provides not only higher resolution product, but also yields superior depiction of gradients.

With improvements in quality and coverage single field-of-view soundings should prove beneficial to several entities within the meteorological community. These soundings are better suited for analysis by forecasters than are the lower resolution options. Also, these soundings are more in line with what will be useful to the NWP community. With better quality and coverage, the single field-of-view GOES soundings are simply a better product than the current operationally available 5x5 GOES soundings or the 3x3 GOES soundings.

REFERENCES:

Ma, Xia, L., T. J. Schmit, and W. L. Smith, 1999: A non-linear physical retrieval algorithm – its application to the GOES-8/9 sounder. *Journal of Applied Meteorology*, 38, No. 5, 501-513.